NASA SBIR 2022 Phase I Solicitation

H3.09 Human Accommodations

Lead Center: JSC

Participating Center(s): JPL

Scope Title

Human Accommodations for Exploration Missions

Scope Description

Humans have been living and working in low Earth orbit (LEO) for several decades; however, human accommodations such as galley and hygiene facilities are still fairly limited. As mission length and distance increase, these comforts of home will become even more important, and their resource footprint will need to be reduced. Missions to the Moon and Mars will introduce partial gravity where optimal design of human accommodations may be different than in LEO. Additionally, emerging commercial activities in LEO and the lunar vicinity will create a larger demand for human accommodations in space.

Innovative technologies that improve human accommodations over the state of the art are sought in the areas of galley, personal hygiene, laundry, and volumetrically efficient use of space for tasks.

Expected TRL or TRL Range at completion of the Project

3 to 6

Primary Technology Taxonomy

Level 1

TX 06 Human Health, Life Support, and Habitation Systems

Level 2

TX 06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems

Desired Deliverables of Phase I and Phase II

- Prototype
- Hardware

Desired Deliverables Description

Phase I deliverables: Reports demonstrating proof of concept, test data from proof-of-concept studies, and designs leading to Phase II. Phase I tasks should answer critical questions focused on reducing development risk prior to entering Phase II. Conceptual solutions should clearly describe resource requirements such as hardware mass, volume, and power, as well as water use and crew time to operate.

Phase II deliverables: Delivery of technologically mature hardware, including components and subsystems that demonstrate performance over the range of expected spacecraft conditions. Hardware should be evaluated through parametric testing prior to shipment. Reports should include design drawings, safety evaluation, and test data, and analysis. Prototypes should be full scale unless physical verification in 1g is not possible. Robustness must be demonstrated with long-term operation and with periods of intermittent dormancy. System should incorporate safety margins and design features to provide safe operation upon delivery to a NASA.

State of the Art and Critical Gaps

State of the art for most human accommodations is defined by International Space Station (ISS) hardware. For sleep and privacy, crew quarters consist of permanent rack-size compartments that accommodate sleeping bag, privacy, personal wall space, ventilation with limited temperature control, lighting, and personal entertainment. The ISS galley consists of a table, food warmer, and potable water dispenser, which can rehydrate food and drinks with hot or ambient temperature water. A small refrigerator has also been added for food and drink storage. Personal hygiene is accomplished with disposable wipes, wetted towels, no-rinse shampoo, Earth-like oral and hair care and normal clothing that is discarded when it gets too dirty. Housekeeping relies mainly on disposable disinfectant wipes and a vacuum cleaner. On ISS, there is no cooking, sink (handwash), shower, dishwasher, washing machine, or dryer.

Critical gaps include:

Rapid food heating for 4 crewmembers at the same time so that crews can dine together. Ideally, heating of 16 food packages could be accomplished in 30 to 45 minutes with less than 500 W of electricity. Food must be heated in accordance with NASA Standard 3001 and the Human Integration Design Handbook, and all equipment must meet touch temperature limits.

Food refrigeration for long-term storage on the way to and from Mars. Stored food volumes of 2 to 8 m^3, with average packaged food density of 388 kg/m^3, may be required at temperature ranges of -25 to 5 Â°C. Concepts must be volumetrically efficient, mass efficient, and highly reliable since loss of food quality can result in loss of crew performance. Secondary mass penalty for cold stowage should be below 0.2 kg per 1 kg of food. The refrigeration and insulation systems should be efficient enough to run (at steady state) on less than 0.15 W/kg of food frozen at -22 Â°C in a 23 Â°C ambient.

Personal hygiene with less consumables is needed. Currently 0.11 kg/person/day of wet wipes are supplied and the goal is to reduce this below 0.05 kg/person/day.

Water efficient handwash for use in microgravity environment. Soap, water, and crew interface aspects must all be considered.

Clothes washer/dryer combination for use on the Moon (1/6g) or Mars (1/3g) that can clean up to 4.5 kg of cotton, polyester, and wool clothing at a time in less than 7 hours using <50 kg machine mass, <0.3 m^3 external machine volume and <300 W electrical power (Note: 101.3 kPa habitat pressure may be assumed for prototype development).

Devices and systems for volumetrically efficient use of habitable volume in spacecraft. This may include random access stowage concepts where equipment and stowage could be packed together densely and slid open for random access when needed. Such a concept could optimize volumes according to real-time crew needs, while maximizing volume for stowage and equipment. Flexible work surfaces will also be considered. For example, systems that allow the crew to maximize "wall" and "ceiling" as work surfaces in a microgravity environment but allow reconfiguration if the habitat transitions into a gravity environment (i.e., walls and ceilings are less useful, but fold-out table tops or overhead features may deploy on demand). Logistics-2-Living concepts are also of interest, such as secondary stowage structure repurposing for the real-time creation of partitions, furniture, glove-boxes, etc.

Out of Scope:

Proposals are not solicited for toilets nor hardware considered life support systems, including air revitalization, water processing, or waste processing. Lunar dust mitigation technologies are covered elsewhere, but innovative interior surface cleaning including dust removal may be submitted to this subtopic. Crew quarters, exercise devices, and electronic devices for entertainment are not in scope here.

Relevance / Science Traceability

The Logistics Reduction (LR) Project, under the Advanced Exploration Systems (AES) Program, within the Human Exploration and Operations Mission Directorate (HEOMD), is the expected initial customer. The LR Project will consider sponsoring Phase III Small Business Innovation Research (SBIR) activities and assist with technology infusion into NASA Moon-to-Mars missions.

References

- "Life Support Baseline Values and Assumptions Document", NASA/TP-2015â€“218570/Rev. 1
- "NASA SPACEFLIGHT HUMAN-SYSTEM STANDARD VOLUME 2: HUMAN FACTORS, HABITABILITY, AND ENVIRONMENTAL HEALTH", NASA-STD-3001 Vol. 2, https://www.nasa.gov/hhp/standards
- "Human Integration Design Handbook, Revision 1", https://www.nasa.gov/feature/human-integration-design/
- "Dual Use of Packaging on the Moon: Logistics-2-Living", AIAA-2010-6049
- "Lessons Learned for the International Space Station Potable Water Dispenser", ICES-2018-114
- "Will Astronauts Wash Clothes on the Way to Mars?", ICES-2015-53